

CANADIAN ENTITLEMENT DETERMINATION
FOR EARLY CLOSURE OF ARROW
1968-69

This study was made for the purpose of providing an estimate of the incremental Canadian Entitlement to downstream power benefits during 1968-69 based on advancing the initial closure of Arrow from April 1, 1969, to April 1, 1968.

The incremental Canadian Entitlement was computed by first computing a total Canadian Entitlement for 1968-69 with both Arrow and Duncan in the system. The stipulated Canadian Entitlement (191 mw Dependable Capacity and 113 mw Average Energy) for 1968-69 from Columns 4 and 5 of Exhibit B to the Canadian Entitlement Exchange Agreement was subtracted from the computed total Entitlement to obtain the incremental Entitlement from Arrow.

The Canadian Entitlement computations were based on procedures set out in Annex B of the Treaty and in Articles VIII, IX, and X of the Protocol.

The incremental Canadian Entitlements due to the early closure of Arrow were computed to be:

Dependable Capacity = 786 mw

Average Annual Energy= 436 avg. mw

The following tables and charts are attached and summarize the study. Where possible, the illustrations are presented in the same format as used in the November 1963 Technical Report of Work Group No. 1, titled "Determination of Canadian Downstream Power Entitlement."

Table 1. Computations of Canadian Entitlement - 1968-69

The essential elements used in the computations of the Canadian Entitlement as provided in Paragraphs 2 and 3 of Annex B are shown in this table.

Table 2. Summary of Power Regulations for 1968-69 for the Computation of Canadian Entitlement to Downstream Benefits from Early Closure of the Arrow Project

This table summarizes the Step 1, 2, and 3 regulations by projects. Capability data is the actual capability from the regulation studies and do not reflect adjustments for encroachment.

Table 3. Determinations of Load Shape for Steps 2 and 3, 1968-69 Canadian Entitlement Computations

The load shape for Steps 2 and 3 carry the same ratio between each month and the annual average as does the Pacific Northwest area

load. The Northwest area firm loads on this table were based on the current forecast data. The Grand Coulee pumping load is also included in this estimate.

The firm load for Steps 2 and 3 is computed as follows:

- (1) Estimate the hydro prime power;
- (2) Add the thermal from Step 1 less reserve;
- (3) Multiply (2) by the ratio of the area annual average firm load to the area critical period firm load to obtain the annual average firm load for Steps 2 and 3 (the ratio used in these studies were 0.97373 and 0.96621, respectively);
- (4) Pro rate the average annual determined in (3) by months in the ratio that each monthly area load bears to the annual average area load; and
- (5) Subtract the thermal in each month to obtain the monthly firm hydro load. The average annual hydro load for Steps 2 and 3 also becomes the firm energy considered usable according to Annex B, Paragraph 3(a).

Table 4. Estimated Distribution of Canadian Average Annual Energy Entitlement

The 549 mw total gain in average annual usable energy was allocated to each base system project in proportion to its average annual gain. One-half of this allocation is the Canadian Energy Entitlement from each project and is shown in Column (6).

The stipulated Canadian Entitlement for 1968-69 for each project is shown in Column (6). These figures were taken from Exhibit A to the Canadian Entitlement Allocation Agreement and are based on Duncan only.

The Incremental Canadian Energy Entitlement by projects from early closure of Arrow is shown in Column (8) and is equal to Column (6) less Column (7).

Table 5. Estimated Distribution of Canadian Dependable Capacity Entitlement

The total Canadian Dependable Capacity Entitlement of 977 mw was allocated to each base system project in proportion to its gain in prime power and is shown in Column (7). The Stipulated Canadian Entitlement for 1968-69 for Duncan only is shown in Column (8). The Incremental Canadian Capacity Entitlement is shown in Column (9) and is the difference between Columns (7) and (8).

Chart 1 & 2 Secondary Energy Duration Curve, 1968-69, Steps 2 and 3

These charts are the duration curves of the secondary energy for Steps 2 and 3. The secondary energy is the capability each month which exceeds the firm hydro loads shown in Table 3. The usable secondary energy shown in average megawatts for each step is computed in accordance with Annex B, Paragraphs 3(b) and 3(c). The "other usable secondary" was computed on the basis of 40% of the remainder after thermal replacement. The thermal replacement was limited to the existing conventional thermal energy capability after allowance for reserve ($433-22=411$ mw) since the NPR was assumed to be on dual purpose operation and not replaceable.

The following tabulation shows the ordinate values for usable secondary energy:

	<u>Step 2</u>	<u>Step 3</u>
Thermal replacement	<u>411</u>	<u>411</u>
Other	<u>903</u>	<u>1,269</u>
Total - mw	1,314	1,680

BPA - Branch of Power Resources
Power Capabilities Section
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TABLE 1

COMPUTATION OF CANADIAN ENTITLEMENT

1968-69

Generation Figures are in Average Megawatts; Load Factors, in Percent

Determination of Dependable Capacity Credited to Canadian Storage

Critical Period Average Rate of Generation	
With Canadian Storage, Step 2	8,539
Without Canadian Storage, Step 3	7,098
Gain Due to Canadian Storage	<u>1,441</u>
Estimated Average Critical Period Load Factor -- Percent	73,788
Dependable Capacity Gain for Arrow and Duncan <u>1/</u>	1,953
Canadian Share of Dependable Capacity for Arrow and Duncan	977
Less Canadian Dependable Capacity Entitlement for Duncan <u>2/</u>	<u>-191</u>
Canadian Incremental Dependable Capacity for Early Closure of Arrow	786

Determination of Increase in Average Annual Usable EnergyStep 2 (with Canadian Storage)

Annual Firm Hydro Energy	8,289
Thermal Replacement Energy	312
Other Usable Secondary Energy	601
System Annual Average Usable Energy	<u>9,202</u>

Step 3 (without Canadian Storage)

Annual Firm Hydro Energy	6,825
Thermal Replacement Energy	347
Other Usable Secondary Energy	933
System Annual Average Usable Energy	<u>8,105</u>

Average Annual Usable Energy Gain for Arrow and Duncan 1,097

Canadian Share of Average Energy Gain for Arrow and Duncan 549

 Less Canadian Average Energy Entitlement for Duncan 2/ -113

Canadian Incremental Average Energy for Early Closure of Arrow 436

1/ Dependable capacity gain credited to Canadian storage equals gain in critical period average rate of generation divided by the estimated average critical period load factor.

2/ From Exhibit B to the Canadian Entitlement Exchange Agreement.

TABLE 2

SUMMARY OF POWER REGULATIONS FOR 1966-69
FOR THE
COMPUTATION OF CANADIAN ENTITLEMENT
TO DOWNSTREAM BENEFITS FROM
EARLY CLOSURE OF THE DUNCAN PROJECT

PROJECTS	BASIC DATA		STEP 1			STEP 2				STEP 3			
	Number of Units	Installed Peaking Capacity MW	Usable Storage 1000 AF	January Peaking Capability MW	Critical Period Average Generation MW	Usable Storage 1000 AF	January Peaking Capability MW	Critical Period Average Generation MW	Average Annual Generation MW	Usable Storage 1000 AF	January Peaking Capability MW	Critical Period Average Generation MW	Average Annual Generation MW
CANADIAN													
Duncan			1,402			1,402							
Arrow			7,144			7,144							
BASE FEDERAL SYSTEM													
Hungry Horse	4	328	3,161	271	185	3,008	278	199	100	3,008	278	212	101
Albion Falls	3	49	1,155	23	23	1,155	23	24	24	1,155	23	25	24
Grand Coulee	18+2	2,294	5,232	2,283	1,805	5,072	2,269	1,741	1,964	5,072	2,131	1,292	1,747
Chief Joseph	16	1,280		1,280	813		1,280	886	1,061		1,280	676	971
Ice Harbor	3	310		310	163		310	167	231		310	169	231
McNary	14	1,127		1,127	571		1,127	563	785		1,127	471	755
John Day	4 - 9	1,087		1,087	800		1,087	823	966		1,087	688	926
The Dalles	14	1,286		1,286	707		1,286	695	937		1,286	588	900
Bonneville	10	558		558	486		558	480	523		558	416	504
Subtotal		8,319	18,094	8,225	5,633	17,781	8,218	5,578	6,591	17,735	8,083	4,537	6,159
BASE SYSTEM NON-FEDERAL													
Kootenay Lake (Canadian)			817			673				673			
Kerr	3	185	1,219	179	132	1,219	179	142	124	1,219	179	151	124
Thompson Falls	6	40		39	34		39	36	33		39	38	33
Moxon Rapids	4	430	231	419	160		430	170	220		430	178	220
Cabinet Gorge	4	230		230	103		230	106	131		230	111	131
Box Canyon	4	79		79	55		79	58	57		79	61	57
Coeur D'Alene Lake and Long Lake			327			223				223			
Wells	10	820		820	390		820	379	495		820	293	468
Chelan	2	54	677	52	44	676	52	47	43	676	52	49	43
Rocky Beach	7	815		815	558		815	546	654		815	426	606
Rock Island	10	159		158	154		158	153	149		159	126	141
Manapua	10	986		986	486		986	475	628		986	370	591
Priest Rapids	10	912		912	466		912	455	591		912	360	558
Brownlee	4	450	980	450	259	974	450	267	283	974	450	269	284
Oxbow	4	219		219	121		219	127	133		219	129	133
Subtotal		5,379	4,251	5,358	2,982	3,765	5,369	2,961	3,541	3,765	5,370	2,561	3,389
TOTAL BASE SYSTEM HYDRO		13,698	22,345	13,583	8,615	21,546	13,587	8,539	10,132	13,000	13,450	7,098	9,548
ADDITIONAL STEP 1 PROJECTS													
Boundary	4	632		632	355								
Hells Canyon	3	425		425	208								
Spokane River Plants		153		149	81								
Pelton and Round Butte		424	274	398	144								
Subtotal		1,634	274	1,604	788								
Independent Resources		3,579	5,463	3,755	1,735								
TOTAL HYDRO RESOURCES		18,911	28,082	18,942	11,138								
THERMAL RESOURCES													
NPR 1/				786	562								
OTHERS 1/				553	433								
TOTAL THERMAL RESOURCES				1,339	995								
TOTAL RESOURCES (HYDRO AND THERMAL)				20,281	12,133								
RESERVES 2/				1,370	22								
RESOURCES AVAILABLE FOR LOAD				18,911	12,111								
ESTIMATED LOAD													
Pacific Northwest Area				16,151	10,648								
Plus Canadian Entitlement				977	549								
SYSTEM LOAD				17,128	11,197								
SURPLUS OR DEFICIT				1,783	914								
CRITICAL PERIOD													
Starts :				August 1936				September 1936				September 16, 1936	
Ends :				April 15, 1937				April 15, 1937				April 15, 1937	
Length (Months) :				8-1/2 Months				7-1/2 Months				7 Months	
STUDY IDENTIFICATION													
				69-1				69-2				69-3	

1/ Includes 786 mw peak and 562 mw energy from NPR under dual purpose operation, 466 mw peak and 391 mw energy from existing thermal plants, and 87 mw peak and 42 mw energy from miscellaneous contracts.

2/ Peak reserves are 8% of peak load; energy reserves are 5% of thermal plant energy capability not including NPR.

Determination of Load Shape for Steps 2 and 3
1968-69 Canadian Entitlement Computations

Pacific Northwest Area Load				Step 2			Step 3		
	Peak	Avg.	Load Factor Percent	Total Firm Load 1/	Thermal Firm Load	Hydro Firm Load	Total Firm Load 1/	Thermal Firm Load	Hydro Firm Load
July	12,492*	9,520	76.21	8,405	973	7,432	7,077	973	6,104
August	12,720*	9,727	76.47	8,588	973	7,615	7,213	973	6,258
Sept. 1-15	12,887*	9,588	74.40	8,465	973	7,492	7,127	973	6,154
Sept. 16-30	12,887*	9,588	74.40	8,465	973	7,492	7,127	973	6,154
October	13,625*	9,958	73.09	8,792	973	7,819	7,402	973	6,429
November	14,869*	10,685	71.86	9,434	973	8,461	7,943	973	6,970
December	15,514*	11,272	72.66	9,952	973	8,979	8,379	973	7,406
January	16,151*	11,735	72.66	10,361	973	9,388	8,723	973	7,750
February	15,300*	11,393	74.46	10,059	973	9,086	8,469	973	7,496
March	14,697*	10,958	74.56	9,675	973	8,702	8,146	973	7,173
Apr. 1-15	14,093*	10,449	74.14	9,226	973	8,253	7,767	973	6,794
Apr. 16-30	14,093*	10,499	74.50	9,270	973	8,297	7,804	973	6,831
May	13,918*	10,370	74.51	9,156	973	8,183	8,709	973	6,736
June	13,528*	10,260	75.84	9,059	973	8,086	7,627	973	6,654
Crit. Period Avg.		10,648	73.788	9,512	973	8,539	8,071	973	7,098
Annual Average		10,490		9,262	973	8,289	7,798	973	6,825
January Peak	16,151*								
Step 1 Critical Period Aug.1936 - Apr.15, 1937 8-1/2 Months				Critical Period Sept. 1936 - Apr.15, 1937 7-1/2 Months			Critical Period Sept.16, 1936- Apr.15, 1937 7 Months		

1/ Total firm load of Step 2 and Step 3 systems, computed for each system to have an average energy load equivalent to the average energy capability within the critical period and to bear a constant ratio, month by month, to the Pacific Northwest Area Load.

* Figures so marked are peak megawatts. All other figures are monthly or semi-monthly energy in average megawatts.

ESTIMATED DISTRIBUTION OF
CANADIAN AVERAGE ANNUAL ENERGY ENTITLEMENT
1968-69
(Average Megawatts)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Projects	Average Annual Energy			Average Annual Usable Gain Allocation	Canadian Average Energy Entitlement	Stipulated Canadian Entitlement for 1968-69 From Duncan	Stipulated Canadian Entitlement From Early Arrow Closure
	Step 2	Step 3	Gain				
<u>Federal</u>							
Hungry Horse	100	100	-	-	-		
Albeni Falls	24	24	-	-	-		
Grand Coulee	1,964	1,747	217	406	203		
Chief Joseph 1/	1,102	1,010	92	172	86		
Ice Harbor	231	231	-	-	-		
McNary	785	755	30	56	28		
John Day	966	926	40	75	38		
The Dalles	937	900	37	69	34		
Bonneville	523	504	19	36	18		
Total Federal	6,632	6,197	435	814	407	81	326
<u>Non-Federal</u>							
Kerr	124	124	-	-	-		
Thompson Falls	33	33	-	-	-		
Noxon Rapids	220	220	-	-	-		
Cabinet Gorge	131	131	-	-	-		
Box Canyon	57	57	-	-	-		
Wells 1/	454	429	25	47	24	6	18
Rocky Reach 1/	651	603	48	90	45	10	35
Rock Island 1/	235	224	11	21	10	2	8
Wanapum 1/	563	528	35	65	33	7	26
Priest Rapids 1/	570	538	32	60	30	7	23
Chelan 1/	46	46	-	-	-		
Bronwlee	284	284	-	-	-		
Oxbow	133	133	-	-	-		
Total Non-Federal	3,501	3,350	151	283	142	32	110
TOTAL	10,133	9,547	586	1,097	549	113	436

1/ Energy capabilities are adjusted for encroachments.

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TABLE 4

ESTIMATED DISTRIBUTION OF
CANADIAN AVERAGE ANNUAL ENERGY ENTITLEMENT
1968-69
(Megawatts)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Projects	Step 2	Step 3	Gain	Loss	Nom. Prime Power Gain Allocation To Project 2/ 2/	Dependable Capacity Canadian Entitlement 3/ 3/	Stipulated Canadian Entitlement for 1968-69 From Duncan	Incremental Canadian Entitlement From Early Arrow Closure
Federal								
Hungry Horse	199	212	-	13	-	-	-	-
Albeni Falls	24	25	-	1	-	-	-	-
Grand Coulee	1,741	1,292	449	-	434	294	-	-
Chief Joseph 1/	932	717	215	-	208	141	-	-
Ice Harbor	167	169	-	2	-	-	-	-
McNary	563	471	92	-	89	60	-	-
John Day	823	688	135	-	131	89	-	-
The Dalles	695	588	107	-	103	70	-	-
Bonneville	480	416	64	-	62	42	-	-
Total Federal	5,624	4,578	1,062	16	1,027	696	131	565
Non-Federal								
Kerr	142	151	-	9	-	-	-	-
Thompson Falls	36	38	-	2	-	-	-	-
Noxon Rapids	170	178	-	8	-	-	-	-
Cabinet Gorge	106	111	-	5	-	-	-	-
Box Canyon	58	61	-	3	-	-	-	-
Wells 1/	333	252	81	-	78	53	11	42
Rocky Reach 1/	543	423	120	-	116	79	17	62
Rock Island 1/	247	211	36	-	35	24	5	19
Wanapum 1/	400	301	99	-	96	65	14	51
Priest Rapids 1/	436	344	92	-	89	60	13	47
Chelan 1/	50	52	-	2	-	-	-	-
Brownlee	267	269	-	2	-	-	-	-
Oxbow	127	129	-	2	-	-	-	-
Total Non-Federal	2,915	2,520	428	33	414	281	60	221
TOTAL	8,539	7,098	1,490	49	1,441	977	191	786

1/ Energy Capabilities are adjusted for encroachments.

2/ Nominal Power Gain Allocation to Project = Prime Power Gain X $\frac{1441}{1490}$

3/ One Half Depend. Cap. Gain = Nom. Prime Pwr. Allocation X $\frac{977}{1441}$

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TABLE 5



